Prepared for

Santa Clara Valley Water District

Operational Strategies

INVASIVE MUSSEL CONTROL MEASURES AT IMPORTED WATER INTAKES
AGREEMENT # A3369A, PROJECT NO. 91452011

FINAL TECHNICAL MEMORANDUM
AUGUST 2011

MWH

RNT CONSULTING INC

This page left blank intentionally.

This Document Prepared by:

SCVWD

Laura Young

MWH

Matthew Holt

Michael Price

RNT Consulting

Renata Claudi

Tom Prescott

The Authors Wish to Acknowledge the Following Contributors:

SCVWD

Jae Abel

Terri Anderson

Mike Devore

This page left blank intentionally.

Contents

Page

1.0 Introduction 1-1
1.1 Background 1-1
1.2 Purpose and Organization of this Technical Memorandum 1-1

2.0 Overview of Existing Water Supply Operations 2-1
2.1 SBA Delivery to SCVWD 2-2
2.2 San Luis Reservoir Intakes and Facilities 2-3
2.3 Storage in Local Reservoirs 2-4
2.4 Diversions to Creeks and Storage in Groundwater Basins 2-5
2.5 Releases of Water to Bays 2-5
2.6 Existing Monitoring Program for Mussel Detection 2-5

3.0 Operational Strategies for Preventing or Reducing Mussel Impacts 3-1
3.1 Minimal or No Protection Scenario 3-1
3.2 Partial-System Protection Strategy 3-2
  3.2.1 Startup after Arrival of Mussels 3-2
  3.2.2 Timing of Potassium Addition 3-2
  3.2.3 Reduce Storage of Imported Source Water in Local Reservoirs 3-2
  3.2.4 Impacts of Potassium on Non-Target Organisms 3-3
3.3 Full-Barrier Protection Strategy 3-3
  3.3.1 Startup upon Completion 3-3
  3.3.2 Chlorine Dioxide Operations 3-4
  3.3.3 Filter Operation and Performance 3-4
  3.3.4 System Controls 3-4
3.4 San Luis Reservoir Intake Trash Racks 3-4

4.0 References 4-1

Figures

Figure 2-1. Raw Water Conveyance System Map 2-1
Figure 2-2. Raw Water Operations System Flow Diagram 2-2
Figure 2-3. Schematic of San Luis Reservoir and Pacheco Pump Plant 2-3
Figure 2-4. Profile from San Luis Reservoir to Bifurcation Structure 2-4

Abbreviations and Acronyms

AFY	acre-feet per year
cfs	cubic feet per second
CVP	Central Valley Project
District	Santa Clara Valley Water District
dreissenid mussels	zebra and quagga mussels
DSOD	Division of Safety of Dams
Feasibility Study	Feasibility Study of Invasive Mussel Control Measures for Imported Water Facilities
Full-Barrier Strategy	Long-Term, Full-Barrier Protection Strategy Alternative
mg/L	milligrams per liter
msl	mean sea level
O&M	operations and maintenance
Partial-Protection Strategy	Short-Term, Partial-System Protection Strategy Alternative
PWTP	Penitencia Water Treatment Plant
SBA	South Bay Aqueduct
SCVWD	Santa Clara Valley Water District
SWP	State Water Project

1.0 Introduction

The Santa Clara Valley Water District (District, SCVWD) wishes to protect its raw water systems from zebra and quagga mussels (dreissenid mussels) in the event that they become established in the District's imported source water. These non-native, invasive mussels are an environmental and economic nuisance, with the potential to harm ecosystems, affect water system reliability, damage equipment and infrastructure, and require significant investment to control. For the District, infestation of invasive freshwater mussels in source water could result in reduced flows through intake and piping systems, increased energy use to pump water through clogged lines, damage to or impairment of water conveyance equipment, and taste and odor problems for delivered water if these negative impacts are not mitigated.

1.1 Background

The District is already taking proactive measures to keep invasive mussels out of its reservoirs with boating inspections on four reservoirs and closure of boating on others except by special permit (i.e., rowing club, ski club, etc.). The District has conducted mussel vulnerability assessments of three pumping plants, local reservoirs, and water treatment plants. The District has also implemented regular mussel monitoring and has developed an invasive mussel response plan. As part of the Invasive Mussel Control Measures at Imported Water Intakes project, the MWH-RNT team has prepared a technical memorandum on the vulnerability of the District's imported water facilities (RNT, 2010), the Feasibility Study of Invasive Mussel Control Measures for Imported Water Facilities (Feasibility Study) (MWH, 2011a), and the Conceptual Design Report (MWH, 2011b).

1.2 Purpose and Organization of this Technical Memorandum

The purpose of this technical memorandum is to identify operating constraints and recommend operational strategies related to infestation of imported source water by dreissenid mussels and/or the protection strategies that may be utilized to prevent or reduce mussel impacts to the District's raw water system. A summary of relevant existing water supply operations is provided first as a background, followed by operational strategies for three different conditions:

1. Establishment of mussels in imported source water or the District's raw water system prior to completion of mussel protection facilities.

2. Operation of a Short-Term, Partial-System Protection Strategy Alternative (Partial-Protection Strategy) after establishment of mussels in imported source water or the District's raw water system.

3. Operation of a Long-Term, Full-Barrier Protection Strategy Alternative (Full-Barrier Strategy) before and after establishment of mussels in imported source water.

This page left blank intentionally.

2.0 Overview of Existing Water Supply Operations

SCVWD provides watershed stewardship, wholesale water supply, and flood protection for Santa Clara County, California, in the southern San Francisco Bay Area. The District encompasses all of the county’s 1,300 square miles and serves the area’s 15 cities and 1.7 million residents.

Approximately half the water used in the county originates in the Sierra Nevada and is delivered through the Sacramento-San Joaquin River Delta or the Hetch Hetchy Aqueduct system. Most of the remainder comes from local rainfall, which is stored in the water district’s 10 local reservoirs or in the county’s three groundwater basins.

Forty percent of Santa Clara County’s water supply is conveyed through the Sacramento–San Joaquin River Delta. State Water Project (SWP) water is supplied to the north side of the District via the South Bay Aqueduct (SBA) and Central Valley Project (CVP) water is supplied to the south side of the District via San Luis Reservoir and the San Felipe System, as shown on Figures 2-1 and 2-2.

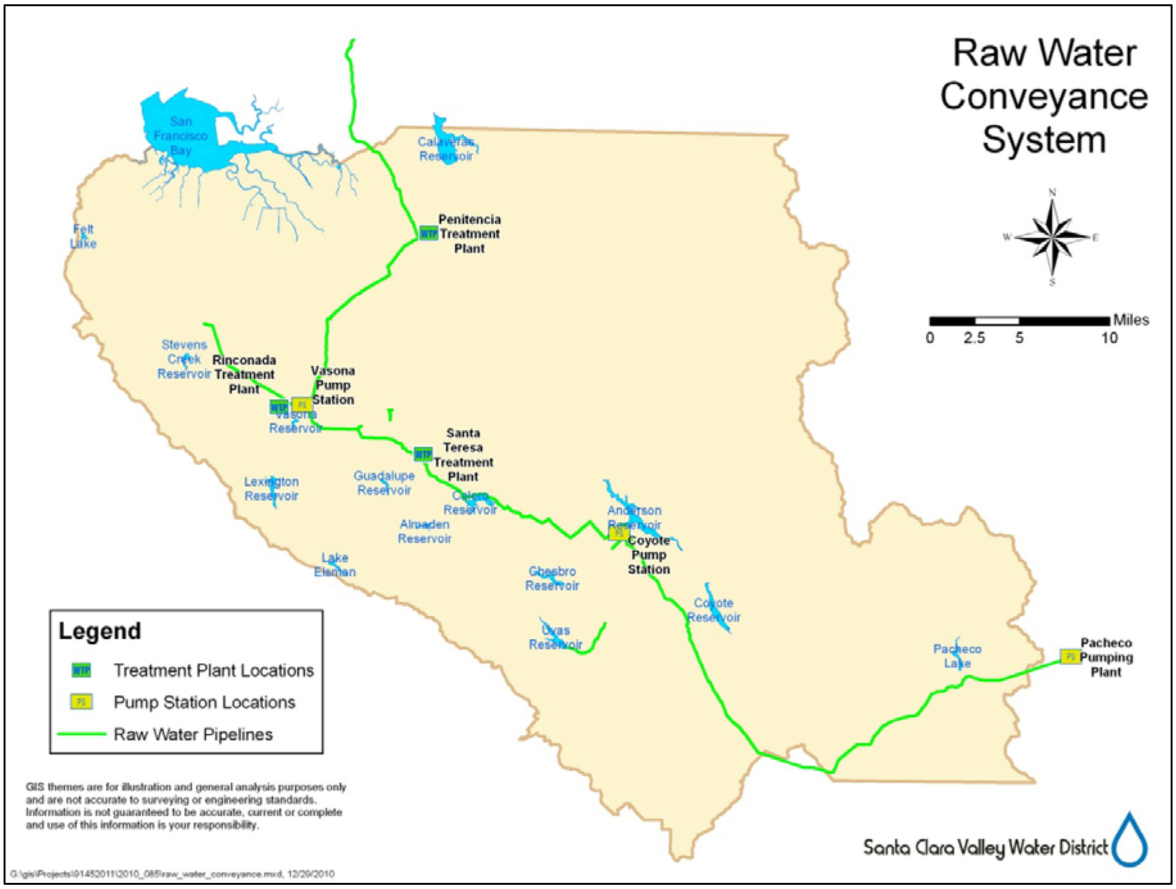
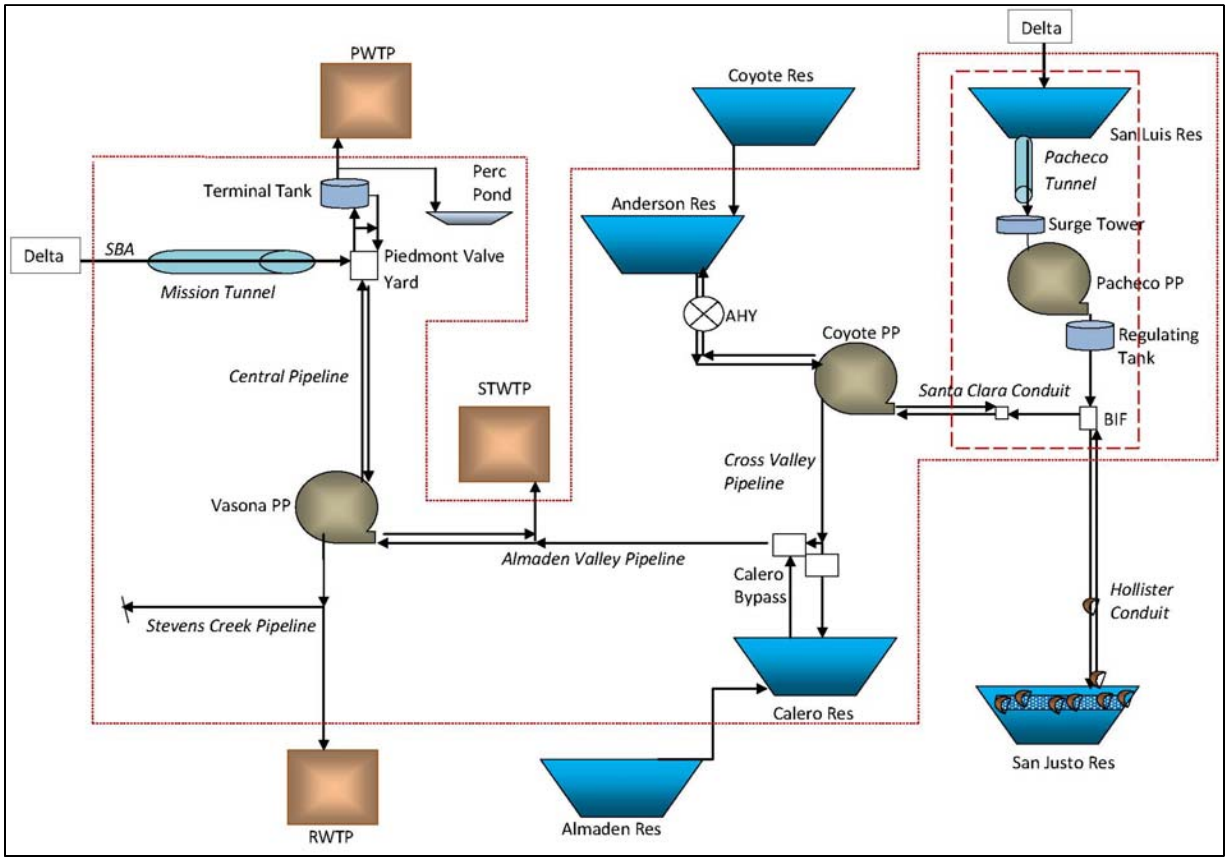

Raw Water Conveyance System
N
W
E
S
Miles
0
2.5
5
10
San Francisco Bay
Calaveras Reservoir
Felt Lake
Penitencia Treatment Plant
WTP
Stevens Creek Reservoir
Rinconada Treatment Plant
Vasona Pump Station
PS
Vasona Reservoir
Santa Teresa Treatment Plant
Lexington Reservoir
Guadalupe Reservoir
Calero Reservoir
Almaden Reservoir
Anderson Reservoir
Coyote Pump Station
Lake Elsman
Chesbro Reservoir
Coyote Reservoir
Uvas Reservoir
Pacheco Lake
Pacheco Pumping Plant
Legend
Treatment Plant Locations
Pump Station Locations
Raw Water Pipelines
GIS themes are for illustration and general analysis purposes only and are not accurate to surveying or engineering standards. Information is not guaranteed to be accurate, current or complete and use of this information is your responsibility.
Santa Clara Valley Water District
G:\gis\Projects\91452011\2010_085\raw_water_conveyance.mxd, 12/29/2010

Figure 2-1. Raw Water Conveyance System Map



Source: L. Young, Santa Clara Valley Water District, December 21, 2010

Figure 2-2. Raw Water Operations System Flow Diagram

2.1 SBA Delivery to SCVWD

The District has a contract to receive 100,000 acre-feet per year (AFY) from the SWP. Statistics summarizing the District's annual receipt of water from the SBA from 1999 through 2010 are shown below:

- Minimum: 28,756 acre-feet
- Median: 59,458 acre-feet
- Average: 61,098 acre-feet
- Maximum: 120,762 acre-feet

The SBA enters the District at the Mission Tunnel and travels approximately 5.6 miles before splitting east to the SBA Terminal Tank at Penitencia Water Treatment Plant (PWTP) and west to the Central Pipeline. Flow rates measured at the Santa Clara Flow Meter Vault on the SBA range from 0 to 185 cubic feet per second (cfs). Typical flow rates are 50 cfs in the winter and 100 cfs in the summer.

2.2 San Luis Reservoir Intakes and Facilities

San Luis Reservoir has a capacity of 2,015,600 acre-feet, with a water surface elevation of 545 feet above mean sea level (msl) when full. There are two SCVWD intakes in San Luis Reservoir, located at elevations 334 and 376 feet msl, as shown on Figure 2-3. The intakes have removable trash racks with relatively wide spacing of vertical bars and horizontal supports. Stainless steel screen mesh with less than 2-inch spacing has been bolted to the outside of the original steel bars to prevent large objects from entering.

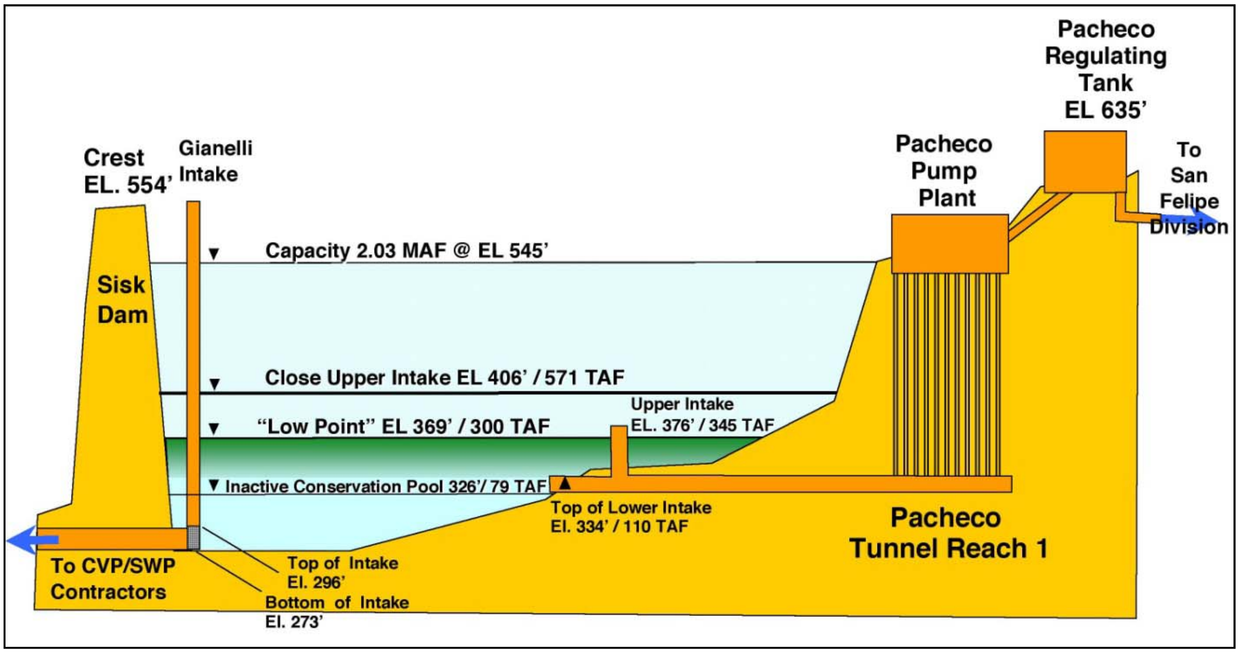

Pacheco Regulating Tank EL 635'
Crest EL. 554'
Gianelli Intake
Pacheco Pump Plant
To San Felipe Division
Capacity 2.03 MAF @ EL 545'
Sisk Dam
Close Upper Intake EL 406' / 571 TAF
Upper Intake EL. 376' / 345 TAF
"Low Point" EL 369' / 300 TAF
Inactive Conservation Pool 326'/ 79 TAF
Top of Lower Intake El. 334' / 110 TAF
Pacheco Tunnel Reach 1
To CVP/SWP Contractors
Top of Intake El. 296'
Bottom of Intake El. 273'

Figure 2-3. Schematic of San Luis Reservoir and Pacheco Pump Plant

The District has a contract to receive 152,500 AFY from the CVP. Statistics summarizing the District's annual receipt of water from San Luis Reservoir from 1999 through 2010 are shown below:

- Minimum: 48,375 acre-feet
- Median: 91,346 acre-feet
- Average: 97,817 acre-feet
- Maximum: 150,516 acre-feet

The Pacheco Pump Plant withdraws water from San Luis Reservoir. Water travels from the intakes to the Pacheco Pump Plant suction vault via the 9.5-foot diameter Pacheco Tunnel. From there, 12 identical vertical-shaft multistage pumps deliver water to a common discharge manifold. The discharge manifold delivers water to a regulating tank for subsequent delivery via gravity into the Pacheco Conduit, as shown in Figure 2-4. From the Pacheco Conduit, water can be delivered to San Benito County via the Hollister Conduit, or to the District via the Santa Clara

Tunnel. Flow rates at the Pacheco Pump Plant range from 0 to 480 cfs. Typical flow rates are 100 cfs in the winter and 350 cfs in the summer.

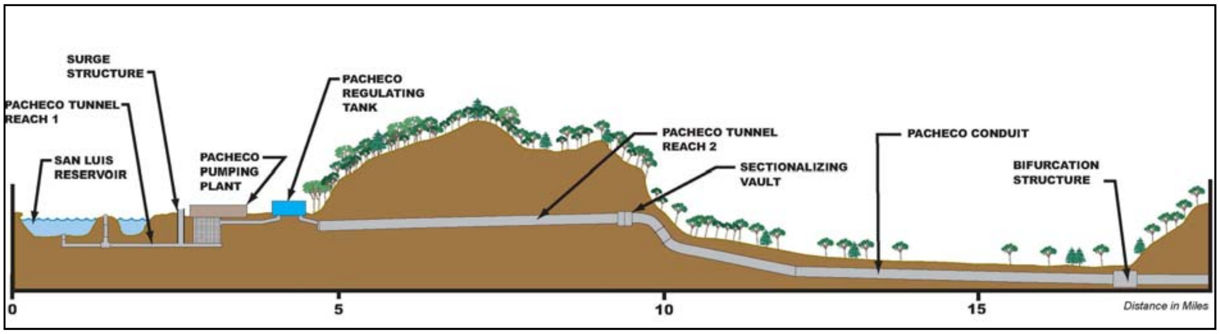


Figure 2-4. Profile from San Luis Reservoir to Bifurcation Structure

2.3 Storage in Local Reservoirs

The District has 10 local reservoirs that capture and store local runoff. The combined local reservoir storage capacity (with Division of Safety of Dams **(**DSOD) restrictions) is 113,758 acre-feet (169,009 acre-feet without DSOD restrictions).

Two of the local reservoirs, Calero and Anderson, can receive water from the raw water system. Calero Reservoir receives water from the following sources (listed greatest to least in terms of water transferred to Calero Reservoir):

- Almaden Reservoir
- Calero Watershed
- San Luis Reservoir
- Anderson and Coyote reservoirs

Water from San Luis Reservoir is typically transferred to Calero Reservoir in the spring and summer. Annual diversions from 2006 through 2010 varied from 493 acre-feet to 5,947 acre-feet. Water from Almaden Reservoir is typically transferred to Calero Reservoir in the winter. Calero Reservoir is frequently used as a flow through reservoir (owing to its separate inlet and outlet) to balance demand throughout the system. The District targets storage of 4,000 acre-feet at the end of the year.

Water from the CVP can also be stored in Anderson Reservoir, but CVP water has not been stored there since 2008 due to the DSOD restriction. Anderson Reservoir will have limited (if any) capability to store CVP water until necessary upgrades lead to lifting of the storage restrictions. Diversions to Anderson Reservoir are pumped through a force main, and water cannot flow to and from Anderson Reservoir simultaneously. In the past, diversions typically occurred between December and March, when the District had storage capacity, extra water, and storage in Anderson Reservoir was more advantageous than storage in San Luis Reservoir.

Statistics summarizing the amount of water from San Luis Reservoir that was stored in Anderson Reservoir from 2001 through 2010 are shown below:

- Minimum: 0 acre-feet (occurred 5 out of 10 years)
- Median: 3,044 acre-feet (using only data from years with storage in Anderson Reservoir)
- Average: 3,361 acre-feet (using only data from years with storage in Anderson Reservoir)
- Maximum: 6,066 acre-feet

2.4 Diversions to Creeks and Storage in Groundwater Basins

In 2009, 102,600 acre-feet of local and imported water entered the subsurface groundwater basins through creeks and recharge facilities. Diversions to the percolation ponds may come from the local reservoirs and creeks, imported water in the raw water system, or a mix of each. Imported water comprises a larger portion of the mix in the summer, but may also be used in the winter when local water has high turbidity (or when the diversion dam is out of service). Imported water can be sent to the creeks year-round, depending on the water supply portfolio.

2.5 Releases of Water to Bays

Flows in creeks that are above and beyond the recharge capability, including flood management releases and fisheries flows, end up in the San Francisco Bay or Monterey Bay. In 2009, 14,800 acre-feet of water was released to the bays. This quantity can vary greatly from year to year and can include imported water.

2.6 Existing Monitoring Program for Mussel Detection

The District’s routine dreissenid mussel monitoring program consists of veliger sampling with plankton tow net and analysis by polymerase chain reaction or cross polarized light microscopy and adult settlement monitoring using artificial substrate samplers. Surface surveys, dive surveys, and ROV inspections may also be performed on an ad hoc basis. Monitoring locations include the SBA (by other agencies), San Luis Reservoir, and District waterbodies that permit recreational boating, contact, and/or fishing. A side-stream biobox installed at the bifurcation structure on the Hollister Conduit to monitor zebra mussels from San Justo Reservoir provides an additional mussel monitoring technique.

This program would provide early detection of mussels if they arrive in imported source water or District water bodies. This information (i.e., the presence or absence of mussels) will be vital for implementing the operational strategies described in Section 3. If mussels do become established, the monitoring program will continue to be valuable for making operational decisions by providing information such as the geographical and temporal changes in mussel populations.

This page left blank intentionally.

3.0 Operational Strategies for Preventing or Reducing Mussel Impacts

The following sections describe the operational strategies, focusing on changes to existing operations, that should be implemented if mussels are detected in the source water or that may result from implementation of a protection strategy.

3.1 Minimal or No Protection Scenario

If mussels arrive in source water before a protection strategy is in place, the following measures should be taken or considered:

- To prevent mussels from establishing populations in local reservoirs, storage of imported water in reservoirs should be discontinued until the Full-Barrier Strategy is in place.[1]
- If storage of imported source water is necessary, subsurface storage of percolated groundwater (through the use of the recharge ponds) would be preferable to storage in the local reservoirs because eradication efforts for recharge ponds would likely be easier and less expensive than in local reservoirs.
- Spot treatments should be performed on a routine basis at all vulnerable equipment in contact with imported source water. The frequency of spot treatments will be dependent on the rate of colonization and may vary from monthly to yearly.
- The Partial-Protection Strategy described in the Conceptual Design Report (MWH, 2011b) should be designed, constructed, and implemented as quickly as possible. Implementation would kill mussels that have settled in the raw water distribution system. Alternatively, one or more of the reactive mitigation alternatives described in the Feasibility Study (MWH, 2011a) could be implemented to achieve similar results.
- Reactive mitigation may be necessary in one or more local reservoirs if it is determined that they have become infested with mussels.

---

[1] During winter months that are not part of the mussel breeding season, there should be no mussel larvae in the imported water sources. However, translocating adults and juveniles would still present a risk for transferring imported water to the local reservoirs unless a method is in place for screening or settling translocating mussels (and comprehensive sampling can show that there are no larvae in the water).

3.2 Partial-System Protection Strategy

The Partial-Protection Strategy presented in the Conceptual Design Report (MWH, 2011b) involves periodic potassium addition to protect large portions of the raw water system downstream of the injection point.

3.2.1 Startup after Arrival of Mussels

Because the chemical addition is periodic and the objective is to minimize the impacts of mussels that enter the raw water system, chemical addition is not necessary unless mussels become established in imported source water or the District's raw water system prior to implementation of the Full-Barrier Strategy.

Note that depending on the construction schedule, chlorine dioxide facilities for the Full-Barrier Strategy may be operational before the mechanical filtration systems. In such a case, the chlorine dioxide facilities could be operated continuously as part of the Partial-Protection Strategy to provide continuous protection of Pacheco Pump Plant and some segments of the raw water pipelines that receive water from the SBA or San Luis Reservoir. Although chemical addition without filters would not necessarily provide protection from juvenile and adult mussels, it would reduce the number viable larval mussels that reach downstream portions of the raw water system and reservoirs.

3.2.2 Timing of Potassium Addition

The Partial-Protection Strategy involves addition of a potassium chloride solution for a 52-day period each year. To reduce the size of the system and annual operations and maintenance (O&M) costs, it is assumed that the potassium addition will occur between the beginning of November and the end of February, when imported water deliveries are typically low. By selecting this particular time of year, it may also be possible to avoid discharging water to Calero Reservoir during the 52-day period, because water from San Luis Reservoir is typically transferred to Calero Reservoir in the spring and summer. By not discharging to local reservoirs, it would reduce the amount of potassium chloride added and some permitting issues may be avoided.

3.2.3 Reduce Storage of Imported Source Water in Local Reservoirs

To reduce the likelihood of mussels establishing populations in local reservoirs, storage of imported water in reservoirs should be reduced or discontinued until the Full-Barrier Strategy is in place. If necessary, transfers of imported water to local reservoirs would be preferable in winter months when the mussels are not breeding.

If storage of water is determined to be necessary, the local reservoir receiving water (e.g., Calero Reservoir) should be closely monitored for establishment of mussels, and if detected, reactive mitigation should be implemented quickly.

3.2.4 Impacts of Potassium on Non-Target Organisms

Potassium can be lethal to other freshwater mollusks[2], which could be a concern if there are native freshwater mollusks in any of the water bodies that receive water from the District's raw water system. There is a native clam that has been identified in some of the District's waters, but not the reservoirs (email correspondence with Jae Abel, SCVWD, April 12, 2011). *Anodonta californiensis*, the California floater, has been located in Llagas and Uvas creeks, headwaters of Coyote Creek, and in Los Gatos Creek near Kirk Dam (email correspondence with Jae Abel, SCVWD, April 12, 2011). The potential for these locations to receive water that may contain potassium during operation of the Partial-Protection Strategy is summarized as follows:

- Uvas Creek would not receive water containing potassium.
- Llagas Creek could receive water containing potassium under some operational circumstances (i.e., spillover of water introduced to the Madrone Channel percolation facility; this linear impoundment set can overflow to West Little Llagas Creek upstream from the confluence with Llagas Creek).
- Coyote Creek receives operational discharges from piping that conveys water to and from Anderson Reservoir. The discharge point is downstream from the areas of native mollusk sightings. It is not known whether a population of the native mollusks exists in the reaches of Coyote Creek that receive imported water, as a survey has not been conducted.
- At Kirk Dam, Los Gatos Creek receives water from the discharge embayment at the Vasona Valve Yard, which contains a blend of water that could include imported source water and water from Lexington Reservoir, among other sources.

The District also has the invasive clam, *Corbicula fluminea*, in its freshwater reservoirs and creeks. Impacts to this invasive species should not present difficulties related to regulatory permitting for the Partial-Protection Strategy.

3.3 Full-Barrier Protection Strategy

The Full-Barrier Strategy presented in the Conceptual Design Report (MWH, 2011b) involves chlorine dioxide addition to kill mussel larvae and mechanical filters to remove translocating juvenile and adult mussels.

3.3.1 Startup upon Completion

The Full-Barrier Strategy uses control methods at imported water entry points to prevent viable mussels from reaching downstream locations within the District's raw water system. If mussels pass the control method locations at a time when the Full-Barrier Strategy is not operating, populations of mussels could become established downstream from the influence of the Full-Barrier Strategy. For this reason, operations should begin upon completion, even if mussels have not yet been detected in imported source water, in case the delay between establishment of mussels and their detection results in mussels passing the Full-Barrier Strategy control points. As described in Section 3.2.1, the chemical facilities may be operating prior to completion of the mechanical filters, depending on the design and construction schedule.

---

[2] Prior to implementation, it may be valuable to determine through literature searches and/or demonstration testing whether potassium (at the concentrations and exposure times expected for this application) may have effects on native invertebrates.

3.3.2 Chlorine Dioxide Operations

Chlorine dioxide dosing and demand and decay should be determined through pilot testing. The assumed dose of 1.4 milligrams per liter (mg/L) has been selected to provide the highest dose that will not lead to chlorite formation above its maximum contaminant level of 1.0 mg/L. The chlorine dioxide maximum residual disinfectant level of 0.8 mg/L is not anticipated to be an issue. Sodium bisulfite addition is assumed to be necessary to remove residual chlorine dioxide prior to release of water to a water body. The recommended locations for sodium bisulfite addition are presented in the Conceptual Design Report (MWH, 2011b).

The Regional Water Quality Control Board, San Francisco Bay Region, has set effluent limits, which are based on Public Health Goals, for some disinfection by-products (including chlorite) in water discharged to surface water bodies for 250 or more days per year. The use of chlorine dioxide would lead to chlorite concentrations above the Public Health Goal of 0.05 mg/L, but this would not likely constrain storage of imported source water at local reservoirs, assuming that water is discharged less than 250 days per year to any one reservoir.

3.3.3 Filter Operation and Performance

The filter systems presented in the Conceptual Design Report (MWH, 2011b) are designed to treat the maximum flow rates at Santa Clara Meter Vault (with one standby filter) and Pacheco Pump Plant (with two standby filters) with an assumed total suspended solids concentration of less than 35 mg/L. Having multiple filters in parallel will provide flexibility to operate different combinations for a range of flow rates and solids loads. If the suspended solids concentration exceeds 35 mg/L (e.g., during turbidity spikes or algae blooms), individual filter performance may decrease below the assumed capacity, potentially limiting the system flow rate. The District may wish to perform pilot testing of two or more makes and models of mechanical filters to gain insight into the performance of filters over the full range of operating conditions.

3.3.4 System Controls

The instrumentation and controls for the Full-Barrier Strategy should be carefully designed to minimize the potential for operator error or system malfunction that could lead to release of untreated water beyond the control points. Additionally, the chlorine dioxide injection system in Pacheco Tunnel Reach 1 should be precisely coordinated with operation of pumps at Pacheco Pump Plant to prevent accidental release of chemicals into San Luis Reservoir through the intakes.

3.4 San Luis Reservoir Intake Trash Racks

If mussels become established in San Luis Reservoir, the existing trash racks on the intakes should be inspected every 3 months during the breeding season (assumed to be April through November, for approximately 3 inspections per year). Once the trash racks have a foul-release coating, the inspection frequency can be reduced progressively based on the rate of colonization.

Every 12 months would be the minimum inspection frequency. The frequency of cleaning will be dependent on the rate of the colonization.

This page left blank intentionally.

4.0 References

MWH, 2011a. Feasibility Study of Invasive Mussel Control Measures for Imported Water Facilities. July.

MWH, 2011b. Conceptual Design Report. July.

RNT Consulting, Inc. (RNT), 2010. Vulnerability of Santa Clara Valley Water District Imported Water Facilities and Potential Impacts from Invasive Dreissenid Mussels. September 24.

This page left blank intentionally.

mwhglobal.com

MWH®

BUILDING A BETTER WORLD

2121 N. California Blvd, Suite 600
Walnut Creek, CA 94596
TEL 925 627 4500